Electrodialysis with bipolar membranes for the sustainable production of chemicals from seawater brines at pilot plant scale

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Introduction

Environmental concerns, arising from the disposal of seawater reverse osmosis brines, necessitate the development of new valorisation strategies. To this purpose, innovative processes are needed to recover high-value compounds from these waste streams. ElectroDialysis with Bipolar Membranes (EDBM) is an emerging electro-membrane technology capable of producing acid and base solution from the corresponding salty solution, employing only electrical energy and water. EDBM technology could be integrated, using circular economy approach, with a desalination plant, thus valorising the produced brine. The acid and base stream results particularly useful for the desalination plant itself for: pre-treatments, membranes cleaning and pH adjustments. The aim of the present work is to evaluate, for the first time, the performances of a large scale EDBM pilot plant (total membrane area 19.2 m^2) testing three different process configurations (both continuous and discontinuous) at different current densities (200-500 A/m^2).

Method

A total number of 10 tests were conducted with the EDBM pilot plant: (i) 4 tests in Closed-Loop mode (discontinuous), (ii) 4 tests in Feed & Bleed mode (continuous) and (iii) 2 tests in Fed-Batch mode (discontinuous). For each test, a target concentration of 1 M of base was reached. Specific Energy Consumption (SEC), Current Efficiency (CE) and Specific Production (SP) were employed as performance indicators in order to analyze the unit.

Results and discussion

At the lower applied current density (200 A m^{-2}), the closed-loop had a lower SEC (1.4 kWh kg^{-1}) and a higher CE (80%). When the current density was increased (300–500 A m^{-2}), the feed & bleed mode was found to be more appropriate due to its low values of SEC (1.9–2.6 kWh kg^{-1}) as well as high values of SP (0.82–1.3 ton y^{-1} m^{-2}) and CE (63–67%). These results show the effect of various process configurations on the performances of the EDBM unit,

guiding to the selection of the most suitable process configuration when varying the operating conditions. This work represents a first important step towards the implementation of this technology at industrial scale.

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